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Ecosystem Effects of Superfund. National Priority List Sites in Industrial Landscapes: A Framework for Policy Decisions

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What is the best way to comply with the spirit of Superfund legislation in environmental protection for National Priority List Sites having ecosystem effects that are located in industrial settings where long term environmental effects will be difficult to prevent due to the industrial setting? A review of pertinent literature was conducted in order to develop a framework for EPA personnel who are developing policy decisions in this area. It is recommended that a landscape perspective be taken in order to account for the cumulative, long term effects of the industrial setting. Such effects may be much more significant than the toxic waste site itself, and thus options such as creation or purchase of additional natural acreage elsewhere may make more ecological sense. The placing of the Superfund effort in a landscape perspective requires a national, multiagency and interdisciplinary landscape management plan in order to be feasible.

Regardless of the decision made in dealing with these types of NPL sites, a broadened approach must be taken that considers long term economic effects, and the overall goal of society. Types of questions that need to be considered, as well as possible approaches that can be used to achieve these ends are given

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ECOSYSTEM EFFECTS OF SUPERFUND NATIONAL PRIORITY LIST SITES IN INDUSTRIAL LANDSCAPES: A FRAMEWORK FOR POLICY DECISIONS

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Abstract

What is the best way to comply with the spirit of Superfund legislation in environmental protection for National Priority List sites having ecosystem effects that are located in industrial settings where long term environmental effects will be difficult to prevent due to the industrial setting? A review of pertinent literature was conducted in order to develop a framework for EPA personnel who are developing policy decisions in this area. It is recommended that a landscape perspective be taken in order to account for the cumulative, long term effects of the industrial setting. Such effects may be much more significant than the toxic waste site itself, and thus options such as creation or purchase of additional natural acreage elsewhere may make more ecological sense. The placing of the Superfund effort in a landscape perspective requires a national, multiagency and interdisciplinary landscape management plan in order to be feasible.

Regardless of the decision made in dealing with these types of NPL sites, a broadened approach must be taken that considers long term economic effects, and the overall goal of society. Types of questions that need to be considered, as well as possible approaches that can be used to achieve these ends are given.

Introduction

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), commonly known as Superfund, was the response by the federal government to increasing public outcry against toxic substances in the environment. As amended by the Superfund Reauthorization Act of 1986 (SARA), it commissioned the EPA to protect both human and ecosystem health from adverse effects due to abandoned hazardous waste sites. While primary emphasis continues to be the protection of human health, the EPA is increasing its ability to assess and correct for ecosystem effects (e.g. USEPA, 1989a).

Under CERCLA, one of two responses can be undertaken to releases or threatened releases of a toxic substance into the environment: a) removal actions, or b) remedial actions. Removal actions are short term emergency measures, while remedial actions are designed to provide longer term protection of the environment. Remedial actions can only be undertaken on hazardous waste sites on the National Priority List (NPL). The revised National Contingency Plan (NCP), as required by SARA, states that remedial investigation of a site should determine "whether the site poses a current or potential risk to human health and the environment in the absence of any remedial action." A remedial investigation includes both assessment of environmental exposures and environmental toxicity to ecological receptors. The NCP also states that "Superfund remedies will... be protective of environmental organisms and ecosystems." CERCLA

requires that remedial action taken at a site meet Federal and State standards or requirements that are "applicable or relevant and appropriate requirements" (ARARs). These may include the Clean Water Act, the Endangered Species Act, the Fish and Wildlife Conservation Act, and others.

Among the NPL sites investigated for ecosystem effects, some will be located in industrial settings. Potential ARARs may not be applicable or relevant. The cumulative effects of the industrial landscape may be of much greater significance to the degradation of the local ecosystems than the NPL site itself. In such situations the question becomes "is it worth it?" to clean up the site from toxic hazards, with the goal of protecting ecological receptors, when the overall effect of the industrial landscape will be to degrade the environment anyway.

No explicit guidelines are given in the recent EPA publication Ecological Assessment of Hazardous Waste Sites (1989a) regarding this consideration. At best, the reference states that ecological assessments will vary from site to site. The entire emphasis is limited to the effects of the toxic substances on the local environment. Site to site differences are considered in terms of how they will be affected by toxic compounds. No reference is made to the cumulative detrimental aspects of the landscape in which the site is located. Thus the spatial scale of focus for a typical Superfund site assessment is quite narrow.

Likewise the temporal aspects of a typical ecological

assessment are limited in scope. As mentioned, removal actions are intended to counter immediate threats. Remedial actions, while intended to handle longer term effects, cannot be expected to do so using current methodology. For example, toxicity tests, which can be used in conjunction with field surveys at sites to demonstrate adverse ecological effects, range in duration from only a few to 90 days (USEPA, 1989a). The science of extrapolating these short term, simple demonstrations to predict long term effects of complicated ecosystems is in its infancy. With regard to the temporal variability in the important ecological phenomenon of succession, the Risk Assessment Guidance for Superfund, Volume II (USEPA, 1989b) states that "this series of events is measured in scores of years in undisturbed environments, and is not likely to be important in assessment of Superfund sites." Thus long term effects of NPL sites are not a focus of remediation, and so it is expected that long term effects of a surrounding inhospitable landscape are completely ignored.

While the spatial and temporal aspects of Superfund cleanup efforts are limited, some of the reasons for this are readily understood. Toxic waste sites themselves are usually of small spatial extent. The time, resources, and scientific understanding needed to perform long term tests of ecological effects are very limited. However, some of these same limitations make it more expedient to consider alternate forms of mitigation at certain NPL sites. Under CERCLA, claims against

the fund set aside for cleanup efforts can include money for restoring, replacing, rehabilitating, or acquiring the substantial equivalent of damaged resources. Given the time and money constraints that will always be present, and also given the enormity of the Superfund cleanup task, what is the best way to comply with the spirit of Superfund legislation in dealing with ecosystem effects for NPL sites located in industrial areas where long term environmental effects will be difficult to prevent due to the industrial setting?

As no policy statement has been issued by the EPA as a guideline for handling this type of situation, it is left to the NPL site Remedial Project Manager (RPM) and On Scene Coordinator (OSC) to decide the best course of action. The EPA publication Risk Assessment Guidance for Superfund, Vol II (1989b) states that "Not all sites will require environmental evaluations" since they are "in industrial areas with little if any wildlife." For these types of sites it states that "the RPM or OSC is responsible for determining the level of effort appropriate to the decisions required for each site."

The purpose of this paper is to develop a framework for considering mitigation options for these types of situations. The pros and cons of alternate courses of action will be examined. The aim of this analysis is to provide EPA personnel with knowledgeable ecosystem considerations that would support a policy decision in this area. The analysis will explore relevant considerations in two general areas of thought: ecologic and

social. In both of these realms there is the need to "scale up", i.e. to broaden perspectives. No discipline, organization or legislation exists in a vacuum, and so each must be tempered with its environment. Indeed, the very existence of the EPA was due to increased societal awareness of the interdependencies and complexities of the Biosphere. The EPAs continuing success will depend on its ability to respond further to our increasing awareness.

Ecological Considerations

Landscape Ecology

There is a tendency for narrowness in focus in dealing with environmental problems. This tendency is in contrast to the recent emphasis among ecologists to recognize the complex processes occurring at large spatiotemporal scales (Noss and Harris, 1986). In the hierarchical approach to ecological phenomenon taken by many ecologists, the highest level investigated tended to be the ecosystem, which was generally defined as a homogeneous unit such as a pine forest, an old field, or a desert (O'Neill et al., 1986). While studies performed at this level were successful in understanding ecosystem structure and function, it has been considered that such studies were less successful in solving environmental problems because they did not fit into a larger schema (Golley, 1987). Landscape ecology is emerging more clearly as this larger

schema. A landscape has been defined as a heterogenous land area composed of a cluster of interacting ecosystems, including human dominated ones, that is repeated in similar form throughout (Forman and Godron, 1986). Landscape ecology emphasizes spatial and temporal interactions occurring across heterogenous areas.

Assessment of Cumulative Impacts

With regards to the mission of EPA in the cleanup of toxic sites, a landscape approach may be very useful. The EPA research program designed to assess the cumulative, landscape level impacts on wetland ecosystems is a good example of this approach. It is also very relevant to this discussion since the cumulative effects of industrial areas are the focus. A recent study has shown that an estimated 32% of the Superfund NPL sites appear to be directly associated with a wetland, with an additional 62% of the sites having the potential to affect downslope wetlands (Magistro et al., 1989).

Cumulative impacts are defined as multiple impacts whose effects on the environment cannot be predicted by simply adding the effects of all individual impacts (Hemond and Benoit, 1988). The various methods being developed for evaluating cumulative impacts could be utilized in Superfund site assessments. In contrast to a typical impact assessment that considers only the effects of a particular disturbance (i.e. NPL site), a cumulative assessment increases the spatial and temporal bounds so that the perspective of the natural ecosystems being protected are considered (Preston and Bedford, 1988). For example, wetland

flood storage and water quality functions, which operate at the scale of watersheds, need to considered in terms of watershed level impacts. Impacts to wildlife values of wetlands, however, would need to be considered at the spatial scales of the ranges of the valued species (Preston and Bedford, 1988).

Preston and Bedford (1988) provide a generic format for the evaluation of cumulative effects. Such a format could be utilized in an NPL site assessment. Their approach begins with selection of appropriate boundaries. Then variables of ecosystem structure and function are chosen, as well as descriptive measures of human activities occurring within the boundaries. Relationships between all these variables would need to be defined, including 1) ecosystem function-landscape attribute relationships, which link changes in ecosystem function to changes in landscape structural variables, and 2) landscape attribute-human action relationships.

With these relationships defined, a cumulative evaluation could proceed as follows:

1) inventory human activities within the study area

2) estimate effects of human actions using attribute-action relationship

3) estimate change in ecosystem function using function-attribute relation

A useful matrix for considering the possible cumulative impacts is presented by Risser (1988). Impacts are either classified as time-crowded or space-crowded, and are categorized as either additive in their effects, synergistic, or indirect:

Category	Time	Space
Additive	A	B
Synergistic	C	D
Indirect	E	F

As an example of case A, more frequent inputs of a toxic chemical may be released into the environment, while in case B, the inputs are closer together in space so that effects are not as dissipated. Synergistic effects (C and D) may also have temporal and spatial aspects, with synergistic elements occurring together in space or time. Indirect effects may be delayed either in time or space from the originating disturbance.

While a multitude of methods exist now and will be developed to evaluate these impacts, it is suggested that such a matrix can be used to identify possible cumulative effects. The NPL site investigators would need to examine existing ecological literature pertaining to the ecosystem of concern and the type of interaction identified from the matrix. Thus existing methodologies could be implemented in the assessment of impacts while current literature would be used to evaluate the possibility of cumulative impacts (Risser, 1988).

There are many difficulties in evaluating cumulative impacts. For instance with wetlands, long term studies need to be conducted to identify landscape components critical to water quality functions (Whigham et al., 1988). Management of the hydrologic system in a landscape is hindered by inadequate understanding of hydrologic interactions between atmospheric, ground, and surface water, as well as by a lack of consideration

of uncertainties in measurement (Winter, 1988). With regard to the cumulative impacts to wildlife, ecologists are presently unable to predict the cumulative effect of three or more different disturbances (Harris, 1988).

In spite of these obstacles, progress is being made. By integrating and synthesizing information concerning past ecological conditions and trends for the ecosystems of concern and by emphasizing what is known rather than what is unknown (Hirsch, 1988), a Superfund ecological assessment team could, at least qualitatively, estimate the magnitude of other impacts occurring at an NPL industrial site. If such cumulative impacts cause the toxic wastes to appear insignificant by comparison, alternate actions could be considered which may have not been if cumulative impacts were ignored.

Conservation Criteria

The act of cleaning up a natural ecosystem from toxic substances can be considered as a restoration of a natural area. This restored natural area could be considered as an addition to the nation's nature reserves. While the specific goal of Superfund is hazardous waste cleanup, the legislation must fit into a higher agenda in order to make sense, that being overall environmental protection. From this perspective it is instructive to consider how a restored Superfund site would contribute to nationwide, multi-agency efforts to create a nature reserve system.

Much literature is devoted to the topic of nature reserve

design. Impetus for this discussion has come from the increasing reduction, conversion, and fragmentation of the natural landscape due to human actions (Harris, 1984). Such fragmentation has been cited as a chief cause of decreasing biodiversity and degraded ecosystem functioning (e.g. Hill, 1985; Quinn and Hastings, 1987; Quinn and Harrison, 1988). A variety of methods for evaluating remnant natural areas have been developed. In a recent review, Smith and Theberge (1986) evaluated 22 different systems that have been used to select natural areas for a reserve system. A total of 20 different criteria were used in these systems. What follows are some of the frequently cited criteria that are applicable to the analysis of a natural area impacted by an NPL site:

1) Diversity--Diversity is frequently cited as the main ecological attribute that preserves are created to maintain. Diversity can be considered at various hierarchical levels. While the most common is species diversity, there exists diversity below that level, such as genetic diversity within a species (Odum, 1984). Likewise, indices of landscape diversity have been developed (Forman and Godron, 1986). The literature is replete with methods to estimate diversity (e.g. EPA, 1989) as well as scientific and philosophic rationalization to conserve diversity (e.g. Wilson and Peter, 1988). It may be useful to consider how the protection of a natural area in an industrial setting would contribute to regional or national efforts to conserve diversity.

2) Rarity--Many consider the preservation of rare species or communities to be a high priority in nature reserve design. An endangered species in an area affected by an NPL site presumably will lead to cleanup actions. But the hypothetical case considered in this paper excludes this type of consideration.

3) Naturalness--A rather subjective criteria, naturalness generally implies freedom from human influence. Again, according to the case examined in this report, it may be very unlikely that a natural area in an industrial area would be free from human disturbance, and thus the area may score low by this criteria. However, the subjectiveness of this criteria leaves much room for differences in opinion. Some may consider "natural" or "wild" land to be found only in huge tracts of roadless, uninhabited land, such as is found today in parts of Alaska. Others may enjoy a wilderness experience in a small park in a downtown area.

4) Area--After a seminal work by MacArthur and Wilson (1967) concerning island biogeographic theory, many conservationists tried to apply it to determine the optimal size of nature reserves. According to the theory, there is an equilibrium population size on islands where extinction rates equal immigration rates. This population size would vary with island size and distance from a population source. For years in the literature a debate ensued over whether a single large reserve or several smaller (SLOSS) ones of equal total area conserved more diversity (e.g. Diamond, 1975; Simberloff and

Abele, 1976; Margules et al., 1982). In the 1980s, the species-area relationships were found not to be useful in predicting reserve value due to differences in habitat which confounded analyses, as well as the differences in species which were not accounted for in the total species number (Deshaye and Morisset, 1989). Soule and Simberloff (1986) consider the SLOSS debate to be over. But a rule of thumb in considering potential reserves continues to be "the bigger the better". If the natural area in an industrial setting is small, this may further reduce its importance in a ranking relative to other larger sites.

5) Threat of Human Interference--This criteria, characteristic of conservation actions, would rank high for the hypothetical site. Surrounded by human activities, it would be very likely for the natural area to be destroyed, either by choice for development, or by cumulative impacts, as presented earlier.

6) Representativeness--Whether or not an area contains a wide range of species, both typical of the region as well as rare, is what is considered for this criteria. This could be gauged directly by a census of the area, or indirectly using a geographic information system which could delineate areas with similar land form, vegetation, soils, etc (Mackey et al., 1988; Shirazi, 1984). Numerous land classification schemes have been developed (e.g. Bailey, 1976; Omernik, 1987), and the EPA is developing a Superfund/GIS system to facilitate its NPL site evaluations. These tools could be used for this type of

analysis.

7) Educational Value--While not a prominent criteria in any of the systems examined, this item could be more relevant to the case examined in this paper due to the possibility of urban educational opportunities.

8) Amenity Value--Natural ecosystems provide a variety of services to humans that are non-market in nature (Odum, 1989). These may include climate amelioration, moderation of the hydrologic cycle, and filtration of pollutants. A wetland system, for example, would likely filter water-borne urban and industrial pollutants. Wetlands can remove nitrogen and phosphorus from runoff through such mechanisms as plant uptake, sediment and peat formation, or denitrification (Hemond and Benoit, 1988). A typical industrial pollutant is heavy metals (Lazarus et al., 1970). The typically anoxic sediments of wetlands may facilitate metal precipitation if excess sulfide is present (Hemond and Benoit, 1988). The functioning of a wetland in this respect may require the removal of toxic stress from the system (Delbert Hicks, EPA, personal communication). Thus even though the industrial setting may cause the eventual degradation of the natural system regardless of any toxic cleanup, the ecosystem may provide valuable services while it exists. This consideration would favor a cleanup of the site.

A natural area being considered for remediation actions in a NPL Superfund cleanup could be analyzed according to these and other criteria. Diversity and area of the natural area in

question could be evaluated relatively easily. Estimates of site rarity, naturalness, and representativeness would require an extensive analysis of the entire region since these are relative terms. One option would be to utilize the natural system data bases produced by other conservation organizations, such as The Nature Conservancy (TNC).

A Landscape Management Plan

Beginning in 1974, TNC has developed natural heritage programs in nearly every state. These programs are essentially inventories of elements of diversity such as species, communities, geologic features, etc. The data collected are used in ranking natural areas for acquisition. TNC takes a multilevel approach to conserving diversity. At a fine scale, species of concern are identified; at a course scale, community types are identified (Nature Conservancy, 1981-1984). An expanded course scale, in which heterogenous landscapes containing functional assemblages of communities are identified, has been proposed as a necessary addition (Noss, 1987a).

A natural area adjacent to a NPL site could be considered using TNCs approach. Ranking of sites by TNC is based on quality of the site, condition of the site, viability, and defensibility. Presumably, an area in an industrial setting could score low on all counts, especially in terms of viability and defensibility. A low ranking using TNCs approach could be evidence in favor of other mitigation options for the site.

Noss and Harris (1986) have emphasized the importance of

increasing the spatiotemporal scale of conservation efforts. They have indicated the potential futility of efforts aimed at small sites situated in inhospitable terrain where survivability is low. Four basic shortcomings of typical conservation activities were identified: 1) focusing on the static nature of a site rather than its dynamic nature. The long term dynamics of an industrially located NPL site need to be considered to make realistic decisions; 2) focusing on the content of a reserve rather than on its context. Again, this directly applies to the present discussion; 3) focusing on species diversity rather than on landscape diversity; and 4) focusing on total species diversity rather than native species diversity.

To remedy these short comings, Noss and Harris (1986) proposed a landscape level conservation strategy. Such an approach accounts for the spatial and temporal dynamics occurring at that scale which would be ignored if finer scaled approaches were taken. Components of this strategy are multiple-use modules (MUMs), nodes of diversity, and corridors. MUMs are well protected core areas surrounded by buffers of increasing human land use. Nodes of diversity are areas of exceptional conservation value. Corridors are natural areas that connect nodes. Such an integrated design may make up for inadequacies in individual preserve size, and should facilitate the dispersal of valued species. There are a number of theoretical difficulties in designing landscape reserve systems in non-steady state environments (Baker, 1989), as well as a shortage of necessary

long term data on target species (e.g. Ehrlich and Murphy, 1987). While some shortcomings of this approach have been criticized (e.g. Simberloff and Cox, 1987; c.f. Noss, 1987b), this conservation strategy may be the best to date. In other parts of the globe, such as Europe, landscape management plans are more developed, taking into account not only biologic concerns but also social-economic needs as well (Haase, 1989). This country could benefit by learning from these countries.

Using this perspective, an industrially located NPL site may be valuable as an integrated part of a regional landscape management plan, if one existed. While the natural area associated with the NPL site may not, in itself, be very valuable in terms of conservation criteria, it may function, for example, as a crucial stepping-stone to the dispersal of the biota, even if it is temporary. But lacking such a landscape management plan, the EPA will have to resort to a more narrow, site-by-site analysis of ecosystem health. This approach may be analogous to a physician considering individual organs while ignoring the health of the body.

Practical carrying out of such a plan would require an unprecedented amount of interagency cooperation (Noss, 1987a). The nation's natural areas are presently managed, or mismanaged, by a wide variety of public and private organizations and individuals. They all have their own priorities and management strategies. While it is not feasible to combine areas into one ownership, it is possible to manage the areas as if they were

components of a large ecosystem (Salwasser, 1988). Gilbert (1988), who is working on the development of the Southern Appalachian Project, has commented that the main obstacle to this cooperation may be administrators and managers of agencies who have specific mandates to manage, not resources, and are reluctant to relinquish any control.

Mitigation by Purchase or Creation of Ecosystems

As a mitigation option, money set aside for a Superfund cleanup could be used to purchase natural areas elsewhere that would contribute more to an overall landscape management strategy than would a short-lived, though toxic free, NPL site. Federal involvement in natural areas, which reached a peak in the 1970s through such legislation as the Wilderness Act, the Endangered Species Act, and cost sharing for natural area acquisition through the Land and Water Conservation Fund, saw a steep decline in the 1980s (Juday, 1988). Utilization of Superfund for the purchase of natural areas, in lieu of actions taken at the site, could make very sound ecological sense. "Shopping lists" of highly ranked and available natural areas produced by organizations involved in natural area acquisition, could be referred to. Areas could be chosen that are nearby the site in question, or of a similar ecosystem type. Areas in the US chosen to be preserved have been selected by a rather haphazard process using mostly political, economic, or aesthetic factors rather than an ecologically sound plan (Christensen, 1988). State heritage programs, which are broadening efforts to produce

regional and national inventories, are widely considered to be scientifically sound, sophisticated, and credible. Thus they could be easily consulted in order to maximize the landscape benefits from such a purchase.

As the above option is essentially a "writing off" of a natural area as being beyond hope, it will lead to a net loss of area for the natural area under consideration. Another mitigation option would be to either restore or create a similar ecosystem elsewhere. Restoration, which can be defined as a recreation at a site of the original community that existed there, has played a relatively minor role in conservation strategies thus far (Jordan et al., 1988). In the case considered in this report, restoration of the community is not a viable option, unless the entire industrial landscape is restored too.

Ecosystem creation efforts, which involve the establishment of a community where it did not exist before, have been utilized extensively to mitigate for lost or damaged wetlands. This strategy is often required under section 404 of the Clean Water Act. The technology for wetland creation is still experimental (Wolf et al., 1986). Some have been very skeptical of man-made wetlands, and have concluded that projects thus far have fallen short of restoring ecological functions (e.g. Race, 1985). Others are more optimistic, and feel that it is still too early to tell (e.g. Harvey and Josselyn, 1986). The EPA Wetland Research Program, adopted in 1986, is designed to provide agency

support for personnel faced with mitigation decisions (Kentula, 1987), and could be referred to if this type of action is considered for an NPL site remediation. A wetland in an industrial area may be more practical to mitigate since the practicality of mitigating losses of wetland habitat and functional value decreases as habitat quality increases (Banner, 1979). A wetland, or any ecosystem, in an industrial area may be expected to be under severe stress and may not be operating at full potential. Thus a created ecosystem elsewhere may be more likely to match the ecological function of a stressed system, or may even surpass it, compared to the possibility of mitigating the loss of a more pristine ecosystem.

Savage (1986) presented some shortcomings involved in mitigation of this nature. One weakness is that mitigation may be ineffective or unreasonable. For instance, creating a wetland in an upland site does increase the amount of wetlands to fulfill the "no net loss" goal, but at the same time upland ecosystems are lost. Thus such actions imply that uplands are less valuable ecosystems, which may not be the case. Also, creating an ecosystem where it is not naturally assumes that nature will "cooperate" so that the new system will persist.

Another shortcoming is that benefits of mitigation, which may be based on unproven technology, are much less tangible than the highly tangible costs. It may be much safer for the EPA to clean up toxic substances at a site and fulfill the letter of the law, than to experiment with unproven technologies as well as to

leave an NPL site still contaminated.

Social Factors

Economics

The basic factor underlying the question examined in this report is economic. If there were adequate financial resources available, all toxic sites could be cleaned up, at least as much as would be technically possible. The question of whether there are alternatives to a cleanup at certain sites is one that recognizes the limited resources in the Superfund effort. Economics deals with the allocation of scarce resources among competing ends.

In his analysis of the use of economics for natural environments, Irland (1988) lists some useful economic questions and concepts that can aid in the systematic analysis of the management of natural areas.

1) What is the product? It can be said that the end product of the Superfund effort is healthy ecosystems, at least in terms of the freedom from adverse toxic effects. That the public considers the presence of significant toxic chemicals in the environment as detrimental to the product is explicit in CERCLA. While exactly how this product is to be utilized by the public is not considered in the legislation, consumer demand for it is evident. What about substitution? Substitutability is fundamental to typical economic thought concerning consumer demand. However, in dealing with natural areas, some would

counter with an argument of "irreversibility". Natural areas can be considered irreproducible, similar to great works of art. Connoisseurs do not value reproductions. Thus a purist would not consider that destruction of a Picasso could be mitigated by a Xerox copy. Likewise, a Rembrandt lost may not be considered mitigated by preserving a Michelangelo elsewhere that is in danger of loss. Likewise, societal segments demand authenticity in natural products and may not accept substitutions (Krutilla and Fisher, 1975). Other segments of society may not be as discerning.

2) What is it worth? What is the value of an ecosystem? This depends on who you ask. Some may consider natural areas to be priceless, having an intrinsic value and an intrinsic right to exist apart from any human utilitarian notions. These may consider that a cleanup of an NPL site is essential, even if it is in a context where it will be destroyed anyway. This may be analogous to providing terminally ill patients with a dignified death, while recognizing that a sick person is as valuable as a healthy one. This view of nature has been termed "biocentric".

How can this attitude be reconciled with the scarcity of Superfund resources? One way is to criticize the legislative process that decides how much of the federal budget goes to Superfund. Gilbert (1988) has commented that the real problem is not the scarcity of funds but the allocation of them, and he cites the great difference between money spent on research for destructive weapons and money spent on environmentally

constructive purposes. This view focuses on the lack of the government to adequately respond to the public will.

Another view is to focus on the values of the public. For instance, Americans spent over $296 billion on recreation related consumption in 1986, and over $200 billion on entertainment and reading expenditures (US Dept. of Commerce, 1989). At the same time, polls indicate that people highly value environmental protection. A New York Times article (July 2, 1989) reported results from a New York Times/CBS poll that showed the 1980s were a time of increasing concern for the environment. Nearly 80% of the respondents in the most recent poll agreed that "continuing environmental improvements must be made regardless of cost."

Yet another way to reconcile biocentric concerns with scarce resources is to encourage the research effort designed to develop innovative technology for Superfund cleanups. Biotic technology, where microbes are implemented to destroy or detoxify contaminants, is a good example of this. If this option proves to be successful, the resources now available in Superfund may prove to be more than adequate.

The anthropocentric view, in contrast, considers ecosystem value in terms of what people can get out of them. Traditional market valuation of natural areas has been severely criticized by some (e.g. Daly, 1977; Victor, 1988), since many valuable services provided to people by natural areas are not monetary transactions. To fill this gap, nonmarket evaluations have been undertaken. Contingency valuation, for example, has been used to

determine what a person might be willing to pay for natural area services such as recreational use. Another approach has been to analyze the energy value of ecosystems (e.g. Farber and Costanza, 1987). This technique involves estimating the photosynthetic production of an ecosystem, then converting it to a dollar amount. In contrast to contingency valuation which focuses on demand for resources, which may fluctuate rapidly due to consumer preferences, attitudes, and knowledge, energy analysis focuses on the supply of services (Turner et al., 1988). While the precision of these techniques is lacking, they still may be implemented in a Superfund assessment. The value of the affected ecosystem may be estimated for both before and after cleanup efforts. The estimated value may be compared to other ecosystems under consideration for either purchase or construction, if this mitigation pathway is taken.

3) What will it cost? While the costs of a typical Superfund cleanup are relatively simple to estimate, although by no means free of error, the opportunity costs are not. Opportunity costs are those benefits foregone by pursuing a mutually exclusive alternative. As explained earlier, cleaning up a natural area in an industrial setting may mean that utilization of the cleanup money for other ecologically sound conservation expenditures may be foregone.

Another cost that must be considered is the long term effects of the toxic wastes if the site is not cleaned up and other mitigation options are taken. In the hypothetical case

examined, direct human health considerations are nonexistent. For instance, there may be no evidence of the significant spread of contaminants via any vector to a human receptor. While the realism of this scenario can easily be argued for an NPL site, even if it were true there would be no guarantee that the situation will not change in the future. There may have been serious inadequacies in the site assessment so that certain human risks were overlooked. Or the site itself may change, either through natural causes such as climatic changes or through human induced changes, so that new pathways of exposure are produced. How can the future costs on human health be estimated in this scenario? These considerations alone may be sufficient impetus to clean up a toxic waste site now.

4) Is it worth it? This question has been typically answered by economists using cost-benefit analysis. This method has been considered suitable for the ranking of projects that are instrumental in nature having well defined objectives, but not for setting those objectives initially (Irland, 1988).

A number of criticisms have been directed at this approach. Many criticize the overemphasis on quantification. A variety of costs and benefits related to natural areas may be considered unquantifiable. Those who consider natural areas "priceless" will not be satisfied with attempts at quantification. Also, cost-benefit analysis assumes away the matter of incidence, which is covered in the next section.

Another shortcoming relates to the discounting procedure.

By means of the discount rate, the present value of benefits is worth more than the equivalent benefits in the future (Krutilla and Fischer, 1975). This temporally narrow view, which favors the present over the future, can lead to a "social trap", where short term local decisions may be at variance with long term global goals (Costanza and Daly, 1987). This shortcoming is especially relevant to the present discussion since natural areas may take centuries to recover, if at all, and since the effects of toxic substances may not be apparent in the short term. Thus if cost-benefit analysis were to be used in deciding the question raised in this paper, the scale of the procedure would need to match the scale of the phenomenon examined.

5) Who wins? Who loses? Economists call this question "incidence." If a decision is made not to clean up a site, but to purchase or create an ecosystem elsewhere, the people living or working near the NPL site may lose. They may lose the use of a natural area which may be the only one in the area. As stated earlier, the toxic wastes may become a human health hazard in the long run, affecting local residents. The people benefitting from the "new" ecosystem may be further away, or of different financial status. This type of scenario has been observed, for example, in the construction of highways through urban areas. While typically wealthier suburbanites may greatly benefit from the speedier access to work places, poorer urbanites may suffer from increased noise, pollution, and community fragmentation.

If a cleanup of the NPL site is accomplished, the local

area, both in terms of ecosystem and human health, may benefit, although perhaps only for the short term. The loss of a natural area elsewhere, which could have been avoided if Superfund resources were used for its protection, may mean a loss to a greater number of people, including the local residents, who could have benefitted from a more diverse environment. Clearly incidence is another matter which must be considered.

The Role of Public Participation

Ultimately the decision as to how to best handle the situation presented in this paper depends on what an informed society wants. Daly (1977) has presented an enlightening spectrum (Figure 1) that helps demonstrate this. The ultimate means that society has to use is low entropy matter and energy. This is the stuff that the earth is made of and the energy received from the sun. Through billions of years of evolution, the earth's flora and fauna, including ourselves, have been produced and are perpetuated through the action of ecological processes. Thus ecology becomes fundamental in understanding the entire spectrum. Economics deals with the production and allocation of goods and services, provided ultimately from the ecological processes, so that the intermediate ends of society can be fulfilled. To complete the spectrum, the ultimate end or goal of society must be considered.

While presumably what society wants can be expressed in legislation such as CERCLA, few would agree that any isolated piece of written legislation could adequately express all a

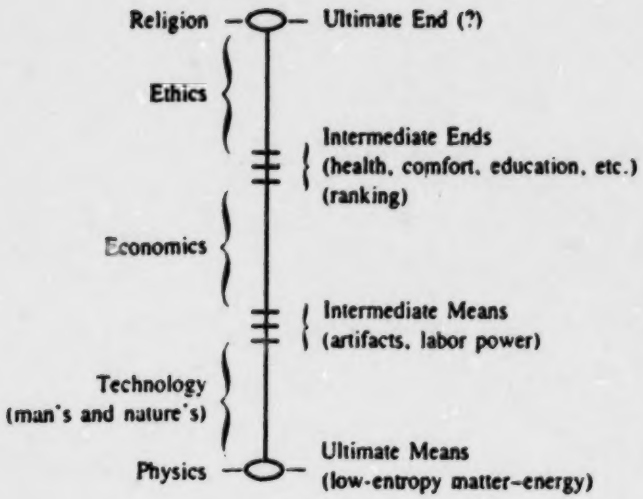

Figure 1. The entire end-means spectrum. Labels on the right refer to the position in the continuum, while labels on the left refer to traditional disciplines that are concerned with that portion of the continuum (from Daly, 1977).

dynamic society wants. Thus public participation becomes a vital part of the actual carrying out of legislation so that these desires can be responded to. The National Research Council report (1986) states that "Environmental assessment and management are based on societal goals, which are not always clearly articulated."

Bowonder (1987) has pointed out that environmental management conflicts arise out of differing perspectives of the problem, and are compounded by such factors as tunnel vision, lack of multidisciplinary understanding, and compartmentalization of the problem. Three basic viewpoints were identified (Figure 2): 1) technical; 2) organizational; and 3) personal. The technical view is governed by methodology, knowledge, data, models, etc. It can be represented in this discussion by landscape ecology and management. The organizational view, which can be represented by government organizations involved in conservation and land management, is governed by group interests and focuses on traditional roles and established procedures. The personal view is that of the public at large, and may include views anywhere along the biocentric-anthropocentric continuum.

To reconcile these views, Bowonder recommends Multiple Perspective Analysis (MPA). The goal of MPA is to bring the three circles together in a stepwise manner by recognizing the different viewpoints, identifying major issues, and by adopting policies that facilitate the merging of the three views.

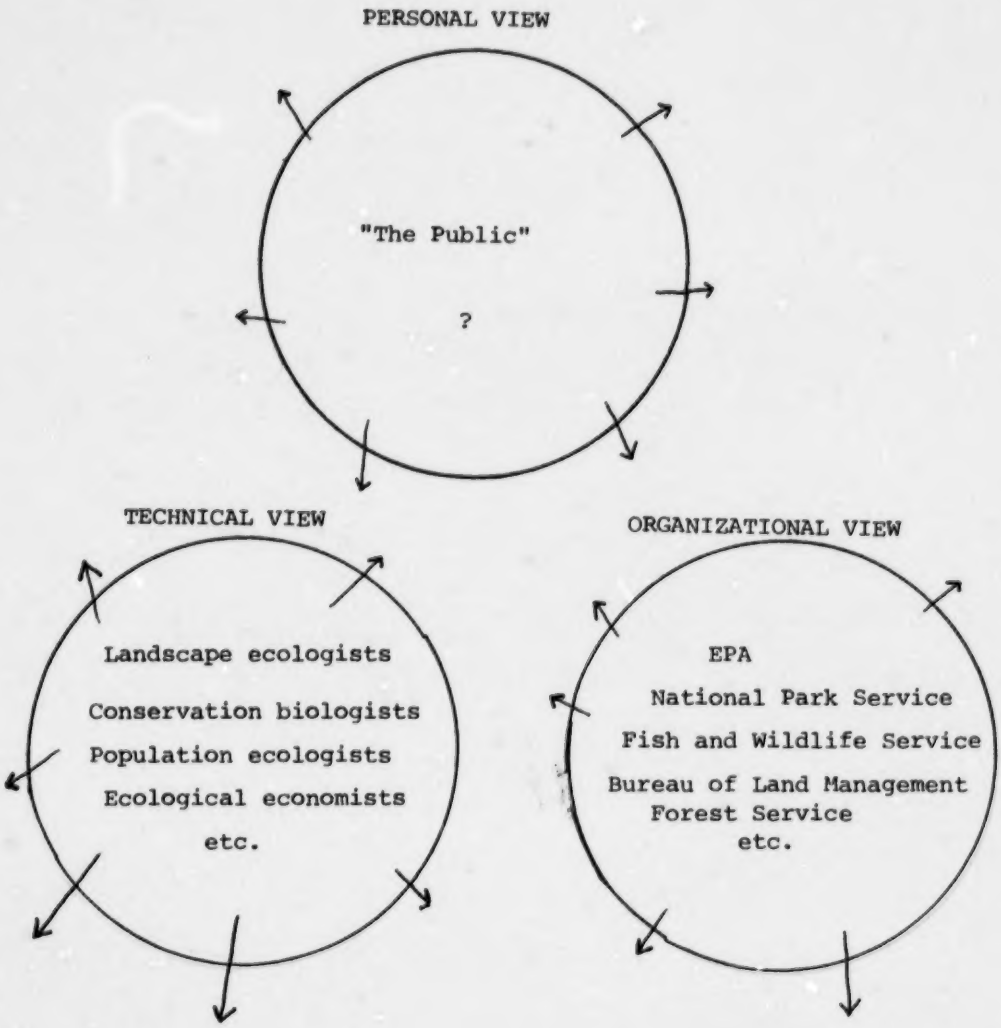

Figure 2. Illustration of divergent viewpoints (circles) and possible behavioral pathways (arrows). Multiple Perspective Analysis seeks to identify pathways that bring about the merger of the three circles (adapted from Bowonder, 1987).

Landscape ecology may demand a rational, holistic management plan that contains knowledgeable ecosystem and realistic, long term economic considerations. The EPA, and other organizations in charge of managing the nations land and resources, may be constrained by legislative mandates and annual budgets. But what does the public want?

Henning (1987) has cited five key functions necessary in a public participation program:

1) identification of interested or affected parties

2) outreach of these parties in a timely, nontechnical format that encourages participation

3) dialogue with the parties via workshops, meetings, etc.

4) assimilation of the public viewpoints into the decisions

5) feedback concerning how public input influenced outcomes.

In this regard, Beanlands and Duinker (1984), commenting on environmental impact statements (EIS), said: "The EIS should begin with social values playing a dominant role in determining valued ecosystem components" and that the process should "solicit the values of both laymen and scientists."

The integration of various views is fundamental to finding the "best" approach to handling the case presented in this paper. The perspectives of all parties involved need to be broadened, not only to understand the ecological aspects involved, but also to realize the decision making process itself. Gaps that exist between technical analysts and policy makers due to superspecialization need to be eroded (Bowonder, 1987). Without

genuine public participation, government organizations may end up dictating social ends, under the label of supplying the public with information, rather than responding to them (Henning, 1987).

Conclusions/Recommendations

We humans are creatures beset with limitations. One of them that has been highlighted in this report is our tendency to be constrained by a narrow spatial and temporal view of the world. Apparently in our evolutionary journey there has been little reason to develop a capacity to detect things that either are much bigger than us or operate very slowly (Ehrlich, 1989). This tendency to focus on the thing at hand reaches its epitome in today's culture, where the scientific disciplines and government organizations are superspecialized. While such specialization has been a reason for our "success", it also is a main reason for our problems.

However, we are also a species noted for its adaptability. In this report I have integrated some literature relative to the question examined. There is an increasing awareness in all realms that narrow, sectarian approaches cannot be very helpful in solving our broad, interconnected environmental problems. The globally oriented view needs to be taken in solving any local problem. To this end, I would recommend that the EPA keep the following considerations in mind when deciding what the best

course of action would be in mitigating a Superfund NPL site having ecosystem effects located in an industrial setting:

1) What are the cumulative ecological effects, taking the perspective of the resources being protected, of the entire industrial landscape? How do they compare with the effects of the toxic waste site itself?

2) How would the presence of the ecosystem of concern contribute to a regional landscape management plan on a long term basis?

3) How might a regional landscape plan be better served if the Superfund money were spent to purchase or create ecosystems elsewhere?

4) What are the long term ecological and human health effects if the NPL site were not cleaned up?

5) How can economic considerations be integrated with ecological ones so as to arrive at a more sensible decision?

6) What is the goal of society? How can public values be better integrated into the decision making process so that it is sensitive to long range public desires?

All of these questions are quite formidable. However I feel that if the EPA continues to move in the direction indicated by these questions, worthwhile answers will be found.

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